2 Data sources

Cable

Revenue per month per subscriber, $42, is from the FCC's annual report on competition in video markets.[2] I simply divided annual revenue per subscriber by 12.

Investment per subscriber is the average price paid per subscriber in all 11 consummated cable company sale from July 1997 to June 1998; TCI is not included in the average.[3] The appropriate measure of investment is the price per subscriber AT&T would receive if it sold its cable companies, because I assume AT&T plans to keep its cable companies, and the cost of keeping them is the value of the foregone opportunity to sell them. Lower figurers are conservative; that is, the value of investment in telephone and broadband Internet transport relative to investment in cable is understated when the investment in cable is understated. The price AT&T paid for TCI was $2,923.[4] AT&T paid even more per subscriber for MediaOne, because its network was more advanced than TCI's.[5]

Phone revenue

Revenue from local telephone service, $45 per subscriber per month, is Merrill Lynch's estimate of revenue MediaOne would have received from its cable telephony service if AT&T had not taken over.[6] Credit Suisse First Boston Corporation says it assumes MediaOne will get $50 per subscriber, and that Cox gets $55.[7] *Telephony* says that second line take rates for many cable operators is 50%, well above the national average.[8]

Toll revenue per residence toll subscriber is from an AT&T statement to the press that "for most consumers, the average monthly long-distance bill is $17."[9] This is conservative in comparison with other data sources. A Fortune magazine article cites Yankee Group data that puts AT&T's toll revenue per residence customer in 1995 at $27, while MCI got $49 and Sprint got $67 per residence customer per month.[10]

Based on customer surveys and focus groups done by AT&T last year, AT&T claims that two-thirds of all customers and more than 90% of high-volume users want to buy a bundle.[11] I assume, conservatively, that only half of AT&T's local cable telephony subscribers will buy AT&T toll service, so the expected toll revenue per local subscriber

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[2] *Annual Assessment of the Status of Competition in Markets for the Delivery of Video Programming*, CS Docket No. 98-102, Federal Communications Commission, 12/17/98, Table B-6.
[3] *Annual Assessment of the Status of Competition in Markets for the Delivery of Video Programming*, CS Docket No. 98-102, Federal Communications Commission, 12/17/98, Table C-4.
[4] *Ibid.*
[5] "AT&T Has Set Itself Some Tough Challenges," *New York Times*, 4/26/99
[6] "Media One Group," Merrill Lynch Capital Markets report, April 30, 1999
[7] "Media One Group," Credit Suisse First Boston Corporation report, 1/7/99
[8] *Telephony*: Chicago; Mar 1, 1999; Blair King; Mitch Matteau; Volume: 236 Issue: 9 Start Page: 38
[9] "Weekend warriors: Sprint fights to gain callers with residential flat-rate plan," *Telephony*, Nov 16, 1998.
[10] "What, Me Worry?", *Fortune*, September 30, 1996, v134 n6 pp. 121-4 at p. 124.
[11] *Forbes*, April 19, 1999 p190(1)

is $8.50. But since AT&T already receives 40% of toll revenues, only 60% of the $$8.50, or $5.10, is incremental toll revenue. The average revenue AT&T will receive from cable telephony subscribers is therefore the $45 from local and $5 from toll, $50. The FCC reports that the average expenditure per household on all telephone services in 1997 was $67.42/mo, 35% more than I assume.[12]

Broadband last-mile transport revenue

Cable operators with a vertically-affiliated ISP keep a fraction of the broadband Internet access subscriber's subscription fee and share in the value of the vertically-affiliated ISP due to its ownership interest. The ISP gets the rest of the subscriber fee, and fees from online transactions and advertising. Under open access, a cable operator would charge all ISPs the same price per subscriber it charges the vertically-affiliated ISP. The cable operator's payoff per subscriber under open access is therefore

$$f(P)+ s(m)[(1-f)P+A+T]$$

where

f = fraction of the subscription fee the cable operator keeps
P = subscription price for broadband Internet access
s = cable operator's share of the vertically-affiliated ISP
m = ISP's market share
A = ISP's advertising revenue
T = ISP's transaction fees from e-commerce

I assume that the cable operator's vertically-affiliated ISP's market share drops to zero, and the ISP's revenues from advertising and e-commerce are both zero, so the cable operator gets simply f(P) per subscriber. I assume that the subscriber fee is $37, and AT&T's fraction is 70%, so AT&T keeps $26.

Investment analysts' reports by both Merrill Lynch and Credit Suisse First Boston Corporation both say that the price MediaOne's subscribers pay for broadband Internet access is $40[13] Credit Suisse First Boston Corporation says that MediaOne's fraction is 70%, or 28. The FCC reports subscription prices for cable modem service between $35 and $60.[14] Jupiter Communications says that subscription prices are between $35 and $40, and cable operators' fraction of that is 70% to 80% with the remainder going to the Internet service provider (i.e., RoadRunner).

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[12] "Trends in Telephone Service," Federal Communications Commission, February 1999, p. 4-3
[13] "Media One Group." Merrill Lynch Capital Markets report, April 30, 1999; "Media One Group," Credit Suisse First Boston Corporation report, 1/7/99.
[14] *Annual Assessment of the Status of Competition in Markets for the Delivery of Video Programming*, CS Docket No. 98-102, Federal Communications Commission, 12/17/98, Table B-9; shares are from Table C-3.

Investment in cable broadband last-mile transport and telephony

I assume that the cost of the investment necessary to produce broadband last-mile transport and cable telephony is $2,350. Jupiter Communications says that the cost of upgrading cable plant to produce broadband Internet transport is $700 to $1,200, assuming a 10% penetration rate.[15] Credit Suisse First Boston reports incremental investment costs for various services, exclusive of the basic cable upgrade. It says the incremental cost of offering telephone service given the underlying cable system upgrade is $800, and the incremental cost of offering broadband Internet access is just the cost of the cable modem, $350.[16] The Jupiter estimate of $700 to $1,200 seems to include the cable modem, but I add it again, just to be conservative. My assumption of $2,350 is comprised of Jupiter's $1,200 for the cable upgrade and Internet transport equipment, Credit Suisse's $800 for telephony, and $350 for a cable modem.

An AT&T press release regarding AT&T telephony joint ventures with small cable companies says that the investment necessary to produce phone service will range from $300 to $500 per home, depending on whether the customer already subscribes to the cable operator's digital video service,[17] well below my estimate of $800.

The FCC says that "high speed cable modem prices are below $350. Many predict that these prices will continue to fall significantly, with one commentator predicting that broadband cable modem prices will be below $150 by the end of 1999."[18] And, as I said, I think I'm double-counting the modem cost.

The investment necessary to produce broadband last-mile transport given that telephony service is already being produced is Credit Suisse Boston's estimate, $350 for the cable modem alone. Milo Medin, Chief Technology Officer for @Home, said in a recent interview that voice services use equipment that is incremental to broadband Internet transport equipment.[19]

Penetration rates

I implicitly assume that penetration for both broadband Internet access and local telephone service is 10%. This assumption is largely for convenience, since the estimate of the cost of a cable system upgrade I used is based on an assumed penetration rate of

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[15] "Last-mile Strategies," Jupiter Communications, August, 1998, (http://www.jup.com/research/bas/samples/reports/9808/).

[16] "Media One Group," Credit Suisse First Boston Corporation report, 1/7/99.

[17] AT&T press release, "AT&T reaches agreements to form commercial joint ventures with five cable operators," 1/8/99, http://www.att.com/press/item/0,1193,275,00.html

[18] *Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996*, CC Docket No. 98-146, Federal Communications Commission, 1/28/99, p. 44

[19] Medin said in his interview that "Since data services don't have the same power requirements as voice, we'll be ready for broadband data before voice" (*Wired Magazine*, April 1999, http://www.wired.com/wired/archive/7.04/medin.html).

10%. This aspect of the method is transparent, since everything is on a per subscriber basis. The table below summarizes the forecasts of penetration rates by other analysts.

	Penetration Rates	
	Internet	Phone
Jupiter[20]	6.9%	
Forrester[21]	12.9%	
Credit Suisse First Boston[22]	11 %	9%
Telephony[23]		10% - 20%
FCC[24]		up to 20% in some areas
British cable companies[25]		20% - 40%

While my assumed rate of penetration for broadband may be a bit high, my assumed rate of penetration for phone service appears to be too low; these two effects are offsetting. But revenue per subscriber is more sensitive to phone service penetration, so the net effect is likely to be to understate revenue per subscriber. However, my analysis is not very sensitive to penetration rate assumptions – I get the same qualitative result even with penetration rates half the lowest forecast.

3 Revenue per dollar of investment is equivalent to the NPV method under simplifying assumptions

My analysis of revenue per dollar of investment is a simplification of the standard method used by economists to evaluate investments: the net present value (NPV) method. Under the assumption that cost characteristics of cable broadband Internet service, such as service lives and margins, are the same as for cable TV service, and that keeping the cable companies rather than selling them is a positive NPV project for AT&T, then advanced services are a positive NPV project if revenue per dollar of investment for advanced services is greater than revenue per dollar of investment for cable services. I present a brief proof and discussion below:

NPV is $$NPV = [\Sigma (R_t - c_t) / (1+r)^t] - I$$

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[20] "Last-mile Strategies," Jupiter Communications, August, 1998, (http://www.jup.com/research/bas/samples/reports/9808/).
[21] "Last-mile Strategies," Jupiter Communications, August, 1998, (http://www.jup.com/research/bas/samples/reports/9808/).
[22] "Media One Group," Credit Suisse First Boston Corporation report, 1/7/99.
[23] *Telephony*; Chicago; Mar 1, 1999; Blair King; Mitch Matteau; Volume: 236 Issue: 9 Start Page: 38
[24] *Annual Assessment of the Status of Competition in Markets for the Delivery of Video Programming*, CS Docket No. 98-102, Federal Communications Commission, 12/17/98, p. 20
[25] "NTL's low-cost multichoice strategy is helping it build market share: The company has a 40% penetration rate in most of its licensed areas-almost twice that of any competitor." ("Telecom-to-order," *Forbes*, July 27, 1998)

Assume that revenue for both classes of service, cable and advanced services, is constant over time at R. Assume further that for each class of service, costs are in the same proportion to revenue, c = kR. This assumption is conservative despite the fact that promotion costs for advanced services are probably higher for advanced services than for cable. Advanced services are incremental to cable operations, so cable costs include overhead, and this probably outweighs the higher cost of promotion of advanced services.

Then $$NPV = R*f - I$$

where f is a constant that depends on k, r, and the time horizon.

Denote cable service with a subscript c and advanced services with a subscript a. Assume that cable service is a positive NPV project and revenue per dollar of investment from advanced services is greater than revenue per dollar of investment from cable. We want to show that these assumptions imply that advanced services is also a positive NPV project. By assumption,

$$R_a f / Ia > R_c f / Ic$$

$$R_c f - I_c > 0$$

We wish to show that

$$R_a f - I_a > 0$$

Beginning with our assumption that

$$R_a f / I_a > R_c f / I_c$$

$$R_a f / I_a - 1 > R_c f / I_c - 1$$

$$(R_a f - I_a) / I_a > (R_c f - I_c) / I_c > 0$$

So

$$NPV_a = R_a f - I_a > 0$$

This completes the proof.

Next, I show that the ratio of dollars per revenue of investment for two different investments is equal to the ratio of the internal rates of return of the two investments, under the assumptions given above. Above, we assumed that costs were proportional to revenues, c=kR. Assuming an infinite time horizon, the internal rate of return on cable is

$$r_c = \alpha R_c / I_c$$

Where $\alpha = (1-k)$. Similarly,

$$r_a = \alpha R_a / I_a$$

So the ratio of the two rates of return is

$$r_a / r_c = (\alpha R_a / I_a) / (\alpha R_c / I_c) = (R_a / I_a) / (R_c / I_c)$$

This is helpful in interpreting the quantitative results of my analysis. For example, I find that revenue per dollar of investment from advanced services is 62% higher than revenue per dollar from cable. If investments in cable facilities are expected to earn a normal

return, then the result I just proved means that advanced services will earn a return 62% above normal.

4 Summary of conservative assumptions

1) I assume no stimulation of quantities due to open access.
2) I assume that @Home's share in ISP market drops to zero under open access
3) I assume that @Home gets no other revenue, such as advertising and on-line transactions fees.
4) My analysis doesn't include costs, just revenue. If costs were taken out of cable investment, it would include overhead, whereas if costs were taken out of incremental investments, it would be only incremental costs, exclusive of overhead.
5) The opportunity cost to AT&T of keeping cable companies is probably understated.
6) The cost of upgrade is probably overstated.
7) Jupiter's cost of upgrade is based on 10% penetration, and telephony services have been getting penetration rates of 10% - 20%; in Britain it's 40% for one carrier offering bundles similar to AT&T's. AT&T will probably get more than other U.S. cable companies because of the value of its brand name and the advantages to consumers of buying a bundle of local and toll telephone service and Internet access. The cost of upgrade per subscriber declines significantly with the penetration rate.
8) The investment in facilities used to provide telephony and broadband Internet access will also be used for cable TV services: additional channel capacity, enhanced transmission quality, and digital TV. The value of these services is assumed to be zero.
9) Much of the investment necessary for broadband Internet has already been made; for customers served by those facilities, the investment necessary to provide broadband Internet access and phone service is much smaller.
10) There is more growth potential in cable telephone and broadband Internet services than in cable TV; cable TV is a mature industry.

Access and Innovation Policy for the Third-Generation Internet

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At various times, past and present, the authors have had occasions to consult with or work for companies and government agencies that have diverse stakes in the outcome of this debate. However, this document reflects only the authors' collective analysis.

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Access and Innovation Policy for the Third-Generation Internet

Abstract

The success of the Internet in the U.S. fundamentally rests on 30 years of consistent FCC policy which sought to maintain network openness by making key network components available to all, on cost-effective terms, so as to foster competition and innovation. The Internet today enters a third phase of its history, when a critical mass of users are about to experience "always-on" high-speed access to the Internet from their home. At this crucial time, the FCC may abandon its successful policy and allow owners of the broadband infrastructure to foreclose access to the infrastructure they own. This is, we show, precisely the wrong time for such a reversal. While the current debate is forced by AT&T's acquisition of TCI, its proposed acquisition of MediaOne, and the companies' ties to Excite@Home, this particular matter simply forces us to address the more general issue. What should be the terms of access to emerging network infrastructures when competition exists, but reflects "collective dominance" of a few players? We argue that policy inaction places network innovation in jeopardy and threatens the continuation of successful infrastructure re-invention.

Keywords: Telecommunications and Internet Policy, Infrastructure Evolution, Broadband Local Loop, Open Access.

Contents

A third-generation Internet is rapidly emerging, in which broadband, always-on access no longer remains the privilege of business users, but becomes available to all. Making this possible is a new residential access infrastructure that offers LAN-like bandwidth for residential users. In addition to substantial upgrades of the second-generation access networks (modems and telephone lines) to DSL, this third-generation access network relies upon the co-axial cables of CATV providers, soon to be augmented by new terrestrial and satellite wireless access methods, even early deployments of fiber-to-the-home. The third-generation internet will be much more than a speedier version of today's internet, just as the current second-generation (epitomized by today's multimedia world wide web) offers much more than a faster access to first-generation text-based gophers, telnet and ftp sessions. The current internet re-invention, like previous rounds, will be driven by the cumulative creativity of multiple users, service providers and equipment makers using this new broadband platform to develop and leverage their ideas.

Or will it? Previous internet innovation cycles largely owed their success to the network's open architecture, a result of consistent FCC policy over the past 30 years. That policy maintained network openness by making key network components available to all, on cost-effective terms, so as to allow competition and innovation. The cable industry, that clearly dominates the early deployment of the internet's third-generation access infrastructure for the residential market, comes from a different policy tradition, where the cable owners control access to their network. As Cable moves from "broadcast" to "broadband", policy-makers are thus faced with an important choice: should the open access requirements developed for previous-generation internet be extended to the new broadband access infrastructures, or will competition among distinct third-generation access networks serves as a substitute for open access and continue to sustain wide-ranging innovation?

This debate was precipitated in the United States by AT&T's 1998 acquisition of TCI, the US largest cable network operator, followed by the company's proposed acquisition of MediaOne in 1999. With the acquisition of TCI came AT&T's control of Excite@Home, the US leading provider of broadband access over cable. AT&T (along with other cable companies) argues that it should retain control over which Internet Service Providers (ISPs) have access to the Excite@Home broadband network, just as cable operators have always controlled which video programs are sent over their network. Government intervention, they argue, is unwarranted, technically unfeasible, and economically counter-productive as it would seriously decrease the company's incentives to upgrade its video network to internet capabilities. Opposing cable's position are a number of local telephone companies (mainly SBC, GTE, Bell Atlantic), ISPs and

consumer organizations arguing for an "open access" policy that would let non-affiliated ISPs offer their service over cable networks just as they are able to do over the telephone network. Open access, they argue, is essential to guarantee consumer choice, to insure fairness in the emerging electronic marketplace and to sustain broad-based innovation and participation in the internet's evolution. In early 2000, AT&T has taken a fledgling step away from complete exclusivity, announcing its intent to let ISP Mindspring offer service on its cable in addition to @Home, once its current contract with @Home expires in 2002.[1] Aside from that, the line-up remains largely unchanged today, with one important exception: America On-Line (AOL), historically a leading advocate of open access, has announced its intention to merger with Time-Warner Cable, thus securing access to a broadband delivery channel of its own. AOL's markets however stretch far beyond Time-Warner's footprint and it remains to be seen how the merger, if it is consummated, will ultimately affect the open access debate overall. AOL so far remains a member of the OpenNET coalition[2] and has pledged to implement open access,[3] although it no longer advocates for regulation requiring open access.

The debate takes place in two distinct policy arenas. At the national level, the FCC repeatedly rejected the idea of "open access". On August 11, 1999, the FCC decided not to open a formal proceeding on access to high speed Internet service[4], although it had previously acknowledged a concern that deployment of closed access Cable systems might reduce competition in the access, or ISP market.[5] FCC Chairman William Kennard later explained that his agency's refusal to intervene was inspired by a "high-tech Hippocratic Oath" to "do no harm."[6]

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[1] A copy of AT&T and Mindspring's letter of intent is available from the FCC's site at http://www.fcc.gov/csb/attmindspringletter.doc

[2] see http://www.opennetcoalition.org/who/, visited May 1st 2000.

[3] "MEMORANDUM OF UNDERSTANDING Between Time Warner Inc. And America Online, Inc. REGARDING OPEN ACCESS BUSINESS PRACTICES", February 29, 2000, available at http://media.web.aol.com/media/press_view.cfm?release_num=25100400

[4] "FCC CHAIRMAN KENNARD SHARES GOAL OF LOCAL GOVERNMENTS TO ACHIEVE OPEN BROADBAND ACCESS. CONTINUES TO BELIEVE THAT VIGILANT RESTRAINT IS THE RIGHT WAY TO GET THERE." FCC Report No: CS-99-11, See also: "Net Access Probe Denied by FCC." *San Jose Mercury News.* August 12, 1999, p. 4C.

[5] Federal Communications Commission (Memorandum Opinion and Order) CS Docket No. 98-178, February 17, 1999. para. 62.

[6] "the FCC has decided not to intervene in this nascent broadband market. In doing so, we are following advice as old as Western civilization itself: First, do no harm--a high-tech Hippocratic Oath.", in "How to End the World Wide Wait", By William E. Kennard, Chairman of the Federal Communications Commission, Op. Ed., *Wall Street Journal,* 24 Aug 1999.

and that he believes non-intervention simply continues the FCC's "unregulation"[7] of the Internet. As we go to press, Chairman Kennard just announced his intent to launch a proceeding on cable access, in response to the June 22, 2000 decision of the U.S. Court of Appeals for the Ninth Circuit in the AT&T v. City of Portland case.[8] In its ruling, the court determined that broadband cable is both a "telecommunications" service and an "information" service, implying that it might be subject to common carrier obligations. While the FCC reaffirmed its "authority to forbear from regulation in this area", its proceeding will aim "to resolve these issues and bring certainty to the marketplace."[9]

US Cable policy is also made by the city governments who grant cable television licenses. In fact, Portland Oregon fired the opening salvo of the debate with its December 1998 decision to require open access as a condition to transfer TCI's existing license to ATT, the new owner. Portland's decision was upheld on first appeal but reversed by the 9th Circuit Court of Appeals. A court in Broward County, Florida, similarly upheld a local law requiring open access, while Virginia overturned such a law --both decisions are being appealed. Other proceedings have followed in other cities (Los Angeles, San Francisco, Miami, Richmond, etc.), none of them currently resolved. In addition, laws requiring open access are currently pending before thirteen state legislatures.[10]

To date, the debate has focused on issues of customer choice and investment incentives, as well as arguments about the proper level of policy-making, federal or local. While these are important, we believe that a critical dimension is missing from this discussion: the impact that the resulting architecture will have on shaping the third-generation internet and its innovation dynamics. History is a useful guide here. In today's debate about open access, as in the last decade's about open network architecture, the dominant owner of an important infrastructure argues against requirements to let in other service providers, lest it would lose incentives to invest

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[7] "The Unregulation of the Internet: Laying a Competitive Course for the Future" Remarks by Chairman Kennard Before the Federal Communications Bar, Northern California Chapter, San Francisco, 7/20/99. The FCC has since re-iterated this position on several occasions: see for example "Consumer Choice Through Competition" Chairman Kennard's Speech at the National Association of Telecommunications Officers and Advisors 19th Annual Conference, September 17, 1999; also Chief of the FCC Cable Services Bureau, Deborah A. Lathen's op-ed, "Driving Ms. Mamie at 1.5 Mbps", Multichannel News, November 8, 1999. Both available from http://www.fcc.gov/broadband/

[8] AT&T, et. al. v. City of Portland, U.S. Court of Appeals, 9th Circuit, Appeal No. 99-35609 (6/22/00).

[9] FCC Chairman to Launch Proceeding on "Cable Access", FCC Press Release, June 30, 2000. (http://www.fcc.gov/Bureaus/Cable/News_Releases/2000/nrcb0017.html)

[10] "Open Access Debate Far From Closure", ZDNet, February 21, 2000

in modernizing its infrastructure. Behind the current argument about the cable TV network, there is a fundamental issue that is unlikely to go away and needs to be confronted.

Indeed, the policy stakes are much larger than the competitive fates of particular groups of ISPs. What is at stake is the continuing evolution of the Internet, the innovation in and the evolution of electronic network-based business, and therefore the competitive development of the network economy as a whole. Closed access, we believe, would undercut the current dynamic of expansion and innovation driven by Internet users and network providers. We should clearly establish the principle that if market power exists, whatever becomes the natural channel of Internet access will have to be configured to allow competition.[11] Openness should depend on clear policy principle, not on corporate discretion.

Beyond the specifics of the AT&T/@Home discussion, we believe that the Commission needs to define the critical elements of "open access" for all providers of broadband service, whether cable or traditional phone companies, through a rulemaking. The answers are not simple. For example, starting from a very different philosophy than the FCC about network development and interconnection, but a shared commitment to strong competition, the British telecom regulator, OFTEL, has pondered a rather inclusive definition of open access for broadband networks. Many participants have argued that policy intervention would be premature. We argue on the contrary, that there is urgency because the competitive development of a broadband Internet system is so rapid that decisions made now will profoundly shape the future trajectory of its development. Any risk of limited competition in access should therefore be scrutinized carefully and immediately. While we sympathize with the worry that regulation always has costs, and is especially tricky in a dynamic technological environment, the FCC's traditional policy principles have been surprisingly robust in dealing with innovation (and fostering it). While the policy instruments need to change the Commission should not undercut its basic principles.

This paper explores this argument in three steps. First, we recount how past FCC policy, with its steady promotion of open access to the telecommunication infrastructure, made the Internet possible. We emphasize that the third generation is a distinct market and, as in the past, the practices concerning its network architecture are vital for competition and innovation. Second

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(http://www.zdnet.com/intweek/stories/news/0,4164,2441098,00.html)

[11] We thoroughly agree with Lawrence Lessig, and have adapted his language here. Lessig, Lawrence. "The Cable Debate, Part II." *Industry Standard.* July 26, 1999. See: http://www.thestandard.net/articles/display/0,1449,5621,00.html

we analyze the current state of competition in the delivery of broadband access infrastructure. Our conclusion is that competition suffers severe restrictions, which offer a poor substitute for open access. Third, we examine cable's argument that open access would stifle investment, and analyze the impact of open access for innovation. Finally, we conclude with suggestions about the possible implementation of such a policy, drawing on international policy discussion, in particular from OFTEL.

I. Network Openness, Internet Evolution, and User-driven Innovation

A. The third-generation internet

Since its emergence about thirty years ago, the internet has undergone constant transformation. We distinguish three successive generations. From the late 1960s to the early 1990s the first-generation Internet was a network and social engineering prototype of interest to military and research organizations. From the early 1990s until today the second-generation Internet saw the mass adoption and commercialization of narrowband access, largely through dialup modems providing intermittent, low-bandwidth connections. The Internet then took full advantage of equal access to key elements of the telephone network, leveraging the universal coverage of the telephone to provide widespread Internet access. The central first-generation applications were file transfers and e-mail, while the explosion of the World Wide Web constituted the main event of the second-generation. Throughout however, except perhaps for a lucky few, slow, intermittent, narrowband connections were the norm for residential use.

We are now entering a third phase of the Internet's history, when a critical mass of users are about to experience "always-on" high-speed access to the Internet from their home. The range and character of services and businesses available on the Internet has mushroomed in the past several years; entire industries and segments of industries are being transformed. In itself this clearly is a new step. But existing services will be used very differently and fundamentally new businesses will come on line with the increased functionality that full-time broadband makes possible. Services such as online banking, interactive video telephony, home networking, and Internet telephony will come of age. Beyond the radical jump in transfer speeds, up to 600 times faster than dial-up, the functions to which a full-time connected broadband network can be turned and the ways it can be used represent a drastic change that will distinguish the "always-on" broadband Internet from its intermittent, narrowband precursor.

In 1990, at the dawn of the second phase of the Internet revolution, nobody had quite envisioned the Web or the influence it would have. Similarly today, no one can tell what will characterize the third phase, but one thing is certain: access to the narrowband world will no more provide reliable access to the services and functions of the broadband world than the monochrome, text-only computer displays in use throughout the Internet's first phase could have done justice to the second-phase web. If our analysis of the first two phases teaches us one thing, it is that the applications and services which will blossom during the third phase will come as a surprise. It is impossible to predict in a next phase of open Internet development either what the value-generating uses of information technology will be, or what optimum network and market structures are necessary to deliver them to users. The answers will emerge through experimentation by users and through competition among those providing users with the tools for that experimentation. This experimentation will include broadband content, video, interactive services, and internet telephony based services, many of which a monopolist provider might like to inhibit. Some important innovations may involve interaction between Web functions and conventional broadcast programming over broadband networks, or the integration of programming and interactive communication within digital set-top boxes. A market and network structure that continues to promote extensive competition throughout the Internet is therefore clearly required.

B. network openness and internet success.

America's remarkable success in promoting the Internet revolution owes a major debt to determined regulatory action that encouraged all aspects of network openness and interconnection.[12] Throughout the first two phases of the Internet's evolution, a large variety of service and content providers could share existing infrastructure, the basic phone network. America Online and other Internet service providers, not the Regional Bell Operating Companies, popularized mass subscriptions to the Internet. Personal computers, the Netscape browser and Cisco, not AT&T, drove the architecture of data networking and the Web. All these innovations were possible because the Federal Communications Commission decided in the 1960s that the emerging world of data networking should not be treated like telecom services. Therefore, it exempted all forms of computer networking from much of telecom's regulatory baggage,

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[12] Oxman, Jason. *The FCC and the Unregulation of the Internet.* (OPP Working Paper No. 31). Washington, D.C.: Federal Communications Commission. July 1999.

including fees to fund various cross-subsidies for telephone services and prevented telephone companies from dictating the architecture of data networks.

Policy intervention, not "unregulation", forced network incumbents to open their networks to these new entrants. The FCC allowed specialized providers of data services, including Internet Service Providers (ISPs) and their customers access to raw network transmission capacity through leased lines on cost-effective terms. In addition to access, FCC policy allowed for flat rate pricing mechanisms for the Internet, largely by exempting ISPs from access charges for data, and it did not impose cross-subsidy requirements on data transport tariffs. The resulting competition allowed the FCC to free the service providers from detailed regulation that would have kept them from using the full capabilities of the network in the most open and free manner. To be sure, the FCC strategy emerged haltingly but its direction never changed. Indeed, the Commission consistently backed cost-based access to the network (initially through leased lines and later through unbundled network elements). The Commission thus supported competition and innovation, time and again, by unfailingly keeping the critical network infrastructure open to new architectures and available to new services on cost-effective terms. The instruments of FCC policy were to make leased lines (and, lately, network elements) available on cost-oriented terms and to forebear from regulating Internet and other data services.

Promoting ever-greater openness of the U.S. telecommunications infrastructure has been a significant theme of U.S. regulatory policy and an important factor in the Internet's success.[13] The FCC chose to unbundle "network elements", the functional elements of the network, rather than to regulate end services. This policy allowed a variety of actors to take basic network building blocks and combine them in diverse and unpredictable ways. Regulating data services, by contrast, would have frozen such experimentation. The major regulatory decisions taken by the FCC over the past 40 years have opened the network and shifted the impetus for telecommunications innovation from incumbent carriers to network users, alternative equipment suppliers and new entrants.[14] Crucially, they protected the competitive space for new entrants to develop into viable commercial firms against entrenched incumbents by mandating interconnection to essential facilities and constraining the incumbents' use of market power.[15]

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[13] Oxman, op. cit.

[14] Policies and proceedings like the *Specialized Common Carrier*, *Carterfone*, *Execunet* and *Open Skies* decisions, and the *First* and *Second Computer Inquiries*, permitted new entry into equipment, network and service provision.

[15] "... established carriers with exchange facilities should, upon request, permit interconnection or leased

These decisions in turn fostered user-driven innovation by giving leading edge users --like financial services, energy and manufacturing firms-- broader access to enhanced facilities and communication capabilities.

A critical group of innovations involved "network performance features". Examples of such features include higher speed connections, variable bandwidth, error rate correction, tailored data services and a diverse and growing array of network management, configuration and billing capabilities. None of these were necessary to provide plain old telephone service and they were therefore largely unavailable from dominant carriers. As it unfolded, the FCC's open network policy contributed to their development and made them broadly available to network users and competitive service providers alike. More recently, the FCC policy of openness has moved to further enhance user-driven innovation and to broaden the possibilities for extended user-choice by enabling deeper access into the incumbent local network. This created the necessary preconditions for the success of Digital Subscriber Lines (DSL) and the rapid funding by the public markets of numerous competitors to the Incumbent Local Exchange Carriers (ILECs) for high-speed data services. These competitors provide a substantial share of DSL access service today. In its *Third Computer Inquiry*, the FCC identified standards for critical software interfaces that were to be made available at affordable tariffed rates.[16] This gradually unfolding U.S. policy to enable user-centered innovation culminated, of course, in the FCC's implementation of the pricing and interconnection provisions of the new Telecommunications Act.

Throughout this history, the monopoly owners of the communications infrastructure strongly resisted opening their network to other service providers. For decades, AT&T resolutely and effectively resisted regulatory requirements to allow interconnection with its network, as the *Carterfone*, *Execunet*, *Open Skies*, and other legal battles all demonstrate. The RBOCs have pursued the same strategy against Open Network Architecture (ONA) and against the unbundling

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channel arrangements on reasonable terms and conditions to be negotiated with the new carriers, and also afford their customers the option of obtaining local distribution service under reasonable terms set forth in the tariff schedules of the local carrier." Moreover, as there stated, "where a carrier has monopoly control over essential facilities we will not condone any policy or practice whereby such carrier would discriminate in favor of an affiliated carrier or show favoritism among competitors." See Federal Communications Commission, 29 F.C.C.2d 870; 1971, para 157. See, also, In the Matter of Use Of The Carterfone Device In Message Toll Telephone Service; Docket No. 16942; 13 F.C.C.2d 420; June 26, 1968; MCI v. FCC (Execunet I), 561 F.2d 365 (D.D.C. 1977), cert. denied, 434 U.S. 1041 (1978); MCI v. FCC (Execunet II), 580 F.2d 590 (D.D.C.), cert. denied 439 U.S. 980 (1978); Computer I, 28 F.C.C.2d 267 (1971); Computer II, 77 F.C.C.2d 384 (1980); Computer III *Notice of Proposed Rulemaking*, F.C.C. 85-397 (Aug. 16, 1985)

[16] See Expanded Interconnection with Local Telephone Company Facilities, (Special Access Order) CC Docket No. 91-141, September 17, 1992; Expanded Interconnection with Local Telephone Company Facilities, (Switched Access Order) CC Docket No. 91-141, August 3, 1993; and *Third Computer Inquiry.*

and interconnection provisions of the 1996 Telecommunications Act. Yet policy persistence paid off, gradually forcing open access to the infrastructure resources the incumbents monopolized. This was the key to the flourishing of a dynamic communications market and the emergence of the Internet. Consistently throughout this history, the FCC rejected claims that networks had to be closed to generate enough investment incentives.[17] In each case the innovative development of the industry with new uses and new suppliers would have suffered had it been forced to develop in a "closed access" mode. Network openness has in fact radically stimulated the use of incumbents' telecom assets such as second lines.

Indeed, US policy has moved gradually and consistently, though not always intentionally and still incompletely, toward support of the new user-driven innovation paradigm. This steady policy set in motion, and sustained, a virtuous cycle of cumulative innovation, new services, infrastructure development, increasing network usage with evident economic benefits for the U.S. economy. Open infrastructure policy fostered user-driven innovation. This meant that the principal sources of new ideas driving economic growth emerged from a long-term process of experimentation and learning, as business and consumer users iteratively adopted and shaped application of information technology and e-commerce. Such user-centered innovation processes flourish when users are granted access to a wide range of choices of facilities, services, and network elements.[18] Furthermore, in an unexpected collateral benefit, the virtuous circle of policy and market innovation came to be recognized by the rest of the world as the right template for network competition and the growth of the Internet. It thus gave the US a voice in global policy that went far beyond its political and market power.

Experimentation by users and competition among providers, across the range of segments that constitute the Internet, generated a surge of self-sustaining innovation. Perhaps the most dramatic single example is the emergence and evolution of the World Wide Web, driven almost entirely by Internet users who pioneered all of its applications. The World Wide Web in turn facilitated a new surge of innovation that has ushered in Internet based e-commerce. This network openness and the user-driven innovation it encouraged were a distinct departure from the prevailing supply-centric, provider-dominated, traditional network model. In that traditional

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[17] For example, the FCC consistently argued that LRIC allowed the sharing of network functions on terms that provided for a competitive return on capital. The furious debate over LRIC for unbundled network elements had this discussion as a critical feature.

[18] Bar, Francois and Michael Borrus, *The Path Not Yet Taken: User-driven Innovation and U.S. Telecommunications Policy*, BRIE, UC Berkeley (mimeo., 1997)

model a dominant carrier or broadcaster offered a limited menu of service options to subscribers; experimentation was limited to small scale trials with the options circumscribed and dictated by the supplier.

By contrast, open access to the network led to rich experimentation by many actors whose ideas had previously been excluded from shaping network evolution. It is a safe bet that few people, back in the days of 300 baud modems, ever thought that 28.8K data communications would flow over ordinary voice phone lines. Even speeds of 9600 bits-per-second were seen as reachable only with expensive, cleaned, better-than-voice lines —ISDN or some similar special service. Diversity of experimentation and competition on an increasingly open network were key, since nobody could foresee what would eventually emerge as successful applications. Openness allowed many paths to be explored, not only those which phone companies, the infrastructure's monopoly owners, would have favored. Absent policy-mandated openness, the Regional Bell Operating Companies (RBOCs) and monopoly franchise CATV networks would certainly have explored only the paths of direct benefit to them. It is doubtful that without such policy-mandated openness the Internet Revolution would have occurred.

Indeed, many of the most successful paths challenged the very core of the phone monopoly business as well as the industry's technology and business assumptions. For example, the Internet is largely distance price insensitive, both because of the character of the emerging technologies and the particular regulatory setting under which they operate. The Internet, where flat-fee pricing had customers pay the same price for one or many e-mails, for sending them around the corner or around the world, forced profound change for the traditional telephone companies.

C. Who ought to shape the Internet's Third Phase?

As we enter this third phase of Internet evolution, the widespread diffusion and adoption of broadband technologies, we face again a similar situation. Locally one provider, the monopoly Cable franchise, with significant market power in key market segments, broadband multi-channel video service to homes and broadband Internet access to homes outside the DSL circle, finds itself in a position to prevent open access to the Internet. Nationally the dominant Cable firm is arguing it should have the right to keep access closed, or at least discretionary. Based on the history we sketched above, this shouldn't come as a surprise. The question is obvious. The successful policy trend of the past thirty years has been to force competition and assure open access to the incumbent infrastructure. Why, now, reverse that successful policy?

There is both a local and national dimension to Cable's power in the market for Internet access. At the local level, Cable providers have substantial market power in the broadband access and broadband service provision, because the Cable franchisee, whether it be AT&T or anyone else, has a complete monopoly over the Cable infrastructure. Local franchises, moreover, only come up for renegotiations episodically or with a change of ownership, further reinforcing Cable's local monopoly power. At the national level, AT&T represents a particularly significant case, because it has become the largest national Cable provider with a position in a majority of local markets. As a result of its recent acquisitions, AT&T now controls the majority of the U.S. cable television infrastructure. Thus, AT&T now has substantial market power over large sections of the present and future broadband Internet, and consequently finds itself in a position to have a profound impact on the Internet's third phase. This share gives it significant influence, beyond the sheer market power indicated by the number of homes passed by a cable system in which AT&T has a significant ownership stake. Indeed, it allows the company to coordinate the activities of many local monopolists and shape the overall network architecture and standards. At the moment AT&T is building a vertical structure in partnership with Excite@Home. The risks and costs of such a closed vertical structure remain even if AT&T only lets in one or a few additional ISP partners.

II. Assessing Competitive Provision of Broadband Access

Clearly, all telecom industry players recognize the importance of this turning point. They have undertaken massive efforts to upgrade existing local telephone and cable infrastructures, and to develop new broadband wireless access. In that respect, the current competitive situation is different from the previous generations, where there clearly was no alternative to Ma Bell's dominant access infrastructure. Yet this doesn't mean that broadband provision is fully competitive, or competitive enough for access not to be an issue: deployment patterns, different regulatory heritage, lead-time of cable, and switching costs result in cable dominance over broadband delivery infrastructure in the short-medium term. Cable providers, which have monopoly cable franchises in most markets, are achieving substantial market power over broadband Internet access.

In our analysis, the relevant market for this policy discussion is the residential broadband access, distinct from narrowband dial-up access. In this, we differ from the FCC's position that it

should not necessarily be viewed separately.[19] The two offer significantly different transfer speeds, with substantial price differences[20] and, as a result, support dramatically different services and applications. To be sure, there is overlap, as broadband connections obviously offer a significant improvement for existing narrowband applications: graphics-intensive web pages load much faster, file transfers complete quickly. But broadband internet is much more than a faster version of the old narrowband internet. Rather, it enables real-time, bandwidth-intensive applications that would be impossible with dial-up narrowband access[21], such as near broadcast quality video streaming, IP-based videoconferencing, or effective connections to a remote LAN. Therefore, the relevant market for our analysis is the market for broadband access, separate from the overall internet access market. In particular, competition from existing ISPs providing narrowband access would not prevent exercise of market power by an ISP that is vertically tied to the owner of broadband access facilities.[22]

A further distinction about relevant market rests on the classes of end users, where the FCC's distinction between residential and business markets makes sense. The third generation Internet marketplace will be driven by the deployment of ubiquitous, "always-on" networking with broadband content into the home. Home networks permanently connected to the Internet, with access appliances or screens in several rooms, are a possible part of this vision, as are interactive video conferencing and low cost internet telephony. But what really distinguishes this phase is the final convergence of TV and PC, of entertainment, education, and work at home, the seamless linking of the home into the larger electronic community. Broadband means many different kinds of content and communication patterns concurrently, "always-on" makes the home

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[19] "the Bureau expresses no view on whether the residential broadband market is a separate market from the residential narrowband market", *Broadband Today*, Deborah A. Lathen, Cable Services Bureau, FCC, October 1999, p. 32.

[20] We recognize that the ISP/portal market and the broadband network access market are different. For the purposes of simplicity we do not spin out the distinctions throughout this paper. In our discussion we treat ISPs as a vertically related market to network access, but we also treat ISPs as a surrogate in some cases for users. We think for our purposes that this suffices. In our conclusion we return to the policy relevant distinction between the ISP and broadband access markets.

[21] Kwok, Timothy C. "Residential broadband Internet services and applications requirements." *IEEE Communications 35* (6). June, 1997. p. 76-83.

[22] For example, it has been argued that we must "forbear from imposing the *Computer II* regime on cable provided-Internet access services," unless "the cable Internet platform currently stands as an essential barrier to ISPs reaching their customers," Esbin, Barbara. *Internet over cable: Defining the future in terms of the past.* (OPP Working Paper No. 30). Washington, D.C.: Federal Communications Commission. August 1998. p. 96. This erroneously assumes that Internet service over a phone line using a modem and over a cable line a cable modem are identical products—if cable modems are the only feasible broadband

a permanent part of the network. Beyond the juxtaposition of traditionally distinct voice, image and data streams on a common wire, this will be marked by their integration within new communication applications. The architecture of the integration point, whether a digital set-top box, a new DSL consumer device, or a home wireless hub, will determine which industry players participate in creating these applications and shape their character.

Naturally, third generation communication applications and patterns of Internet use will not be restricted to the home and will be adapted throughout the economy. But the residential market will play an important role in shaping the third generation Internet and e-commerce evolution because it will bring a population of broadband users large enough to constitute a critical mass able to sustain the development of third generation applications. Again, the particulars of this third generation future are by essence unpredictable, but one might look back to the development of the second generation web for insights. As the Internet became a mass medium during its second phase, the large population of Internet users created justification for continued innovation in browsers and server features. The large population of browser-equipped customers in turn created powerful incentive for merchants to offer electronic commerce applications and build a cyber-marketplace. The mass market thus shaped the unfolding of second generation Internet and the current forms of early electronic commerce. Sustained development of the next generation of applications will similarly require a large enough potential audience of users with broadband network access. Only if there is a critical mass of broadband-enabled users will the full range of broadband application and use patterns be explored. Closing off key segments of the broadband infrastructure to a monopoly provider would inevitably choke off the very innovation that has created value from today's Internet. Thus, the residential broadband access market is relevant not only in terms of the economic analysis of market power, but also in terms of its policy importance.

This section argues that cable and more specifically AT&T, as a result of recent and proposed mergers, dominates residential broadband access. Second, even when residential consumers have a choice of broadband access provider, significant switching costs blunt competitive dynamics, reinforcing cable's lead. This lead is likely to endure through the near term, marking the first five years of broadband access deployment. This initial period is particularly critical because patterns get set early.

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route to the home, such a barrier exists.

A. The deployment of broadband access alternatives

The pace of broadband access infrastructure deployment is picking up quite dramatically. Both CATV operators and incumbents LECs are working hard to upgrade their networks so they can offer broadband internet access. In addition, a number of wireless technologies are now emerging as possible broadband alternatives. These range from "wireless cable" approaches such as MMDS and LMDS, to "High Data Rate" (HDR), Satellite (Tachyon, Spaceway, Teledesic), or "fiberless optics" (Terabeam). Yet, the availability of "last mile" competitive broadband network infrastructure for residential customers remains limited.

For all practical purposes, Cable and DSL are currently the only broadband options available in the residential market and Cable has a substantial lead over DSL. The FCC reports mid-1999 figures showing 1,052,000 cable subscribers versus 159,150 DSL[23]. End-1999 numbers from the Yankee Group peg the total installed base of residential broadband subscribers at 1.4 million, with nearly 80 percent of these homes using cable modems.[24] Others show an even greater cable lead, counting 2,277,750 cable subscribers to 189,500 DSL subscribers at the end of first Quarter 2000.[25] The FCC has just initiated a data gathering program in an effort to better gauge the real extent of broadband access competition[26]. Until results are reported however, we can reasonably accept the most conservative industry estimates, reflecting an 80/20 lead for cable.

Predictions about the future of broadband access competition are more dispersed, although most reports agree that cable's lead probably will endure through the next two years. For example, a McKinsey & Bernstein study pegs 2004 Cable share at 47% (the rest being divided between DSL and new wireless access methods)[27], the Yankee Group predicts that Cable

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[23] *Broadband Today*, Deborah A. Lathen, Cable Services Bureau, FCC, October 1999, p25 and 28.

[24] Yankee Group, "Cable Modems and DSL: High-Speed Growth for High Speed-Access" January 2000, cited in "16 Million+ High-Speed Homes by 2004", ISP Planet, January 2000. (http://www.isp-planet.com/research/broadband_growth-1-28-00.html)

[25] Telecommunications Reports Int'l, "BROADBAND ACCESS: Opportunities and Market Forecasts 2000 - 2004", April 2000, cited in "Report Shows Internet Approaching Oligopoly", ISP Planet, May 2000 (http://www.isp-planet.com/research/census_q12k.html)

[26] "FCC adopts data collection program to Assess Local Telecommunications Competition and Broadband Deployment", FCC press release, 3/14/00, (http://www.fcc.gov/Bureaus/Common_Carrier/News_Releases/2000/nrcc0020.html)

[27] This estimate assumes that ILECs carry through the substantial network upgrades required to deploy DSL technology, and assume significant DSL resale by major ISPs. "Broadband!", A Joint Industry Study by McKinsey and Sanford Bernstein, January 2000

will still control 42% of this market by 2004,[28] while the Cahners Group sees DSL overtaking Cable in 2002.[29]

In our view, there is much support for the predictions that cable will continue to dominate. In particular, only 23% of US households are within 12,000 ft of an upgraded central office, without Digital Loop Carrier (DLC), and therefore can technically received DSL service, while 52% of US households are passed by upgraded two-way cable plant that can technically deliver broadband access.[30] The ratio worsens when one considers only households with annual income over $75,000, who are most likely to be early adopters and profitable customers: 60% of these are addressable by broadband cable, versus 20% by DSL.[31] Ironically, ILECs are handicapped by their recent upgrades, because the DLC equipment they deployed to connect new suburbs make these lines unfit for DSL and will have to be replaced, at a substantial cost. As an example, the price tag of SBC's "project Pronto", its network upgrade initiative aimed at making 80% of its access lines DSL capable by end-2002, carries a $6 billion price tag.[32] By contrast, Cable companies have aggressively deployed digital video services to compete with Direct Broadcast, reaping substantial revenues from that deployment. That investment brings them ever closer to offering broadband data services. While there are certainly additional costs to make digital cable interactive, less than 5-8% of the total bandwidth on a digital Cable system is used for high speed data services; the rest remains available for profitable digital video services. Holding a franchise monopoly for Cable TV thus creates a solid foundation for Cable to enter the market for broadband access.

Overall national figures, whether market share or addressability, provide a misleading picture of the competitive situation. Indeed in the short to medium term, broadband cable and DSL deployments are taking place along two distinct footprints, with relatively limited overlap. The Cable modem footprint generally covers only residential areas and clearly dominates in many suburbs.[33] While we can expect that eventually, most homes will have a choice between two broadband wires, cable and DSL, in the near term most will only have one option, and in most cases that option will be cable. We should also note that a few US cities, notably Palo Alto, CA

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[28] Yankee Group, 2000, op. cit.

[29] "Clash of the Broadband Titans: Cable vs. DSL", Cahners In-Stat Group, February 2000.

[30] Bernstein/McKinsey, op. cit., p 9.

[31] ibid.

[32] See http://www.sbc.com/Technology/data_strategy/project_pronto/Home.html

and Dunwoody, GA, have undertaken fiber-to-the-home trials.[34] At this point however, these remain pricey (e.g. Palo Alto's costs $1200 connection fee, and $92/month for 10 Mbps service, or twice those rates for 100Mbps[35]) and their availability is likely to remain quite limited in the near-term.

In its recent staff report on broadband deployment, the FCC's Cable Services Bureau notes that in addition to these wired approaches, a number of broadband wireless technologies will be offered within a few years.[36] Sprint plans to deploy one such technology, Multichannel Multipoint Distribution Services (MMDS), in 83 US markets over the next two years, offering data rates and prices roughly similar to today's Cable modem and DSL solutions.[37] Like Cable, MMDS is a shared solution (in fact, the technology started out as a "wireless-cable" approach to deliver CATV programming). In addition, it suffers from technical limitations, such as the requirement for line-of-sight connections and susceptibility to bad weather. Others in this general category are "Wireless Competitive Local Exchange Carriers", including Advanced Radio Telecom (ART), NextLink, Teligent and WinStar, who generally plan to focus on providing broadband service to buildings in urban areas that are not served by existing fiber or CLECs.[38] While most will initially focus on business customers, AT&T has just announced the roll-out of "Fixed Wireless" telephone service in areas where it doesn't have agreements with cable operators, providing initial data rates of 256kbps to 512kbps, and up to 1Mb/s by summer's end [39]. However, analysts see MMDS and fixed wireless as niche plays, estimating they will take respectively 8% and 7% of the broadband access market by 2004, primarily in areas where neither cable nor DSL is available.[40] Also on the horizon are an array of other high bandwidth wireless technologies, such as Qualcomm's High Data Rate (HDR) wireless technology, expected

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[33] Freed, Les. *PC Magazine*. March 9, 1999. p. 172.

[34] Hecht, J. "Fiber to the Home", *Technology Review*, March/April 2000 (http://www.techreview.com/articles/ma00/hecht.htm)

[35] See "Fiber to the Home (FTTH) Trial" (http://www.city.palo-alto.ca.us/utilities/fth/index.html)

[36] "Broadband Today", op. cit. p. 29

[37] "Sprint Rolls out Wireless Cable: Ubiquitous Broadband Coverage Planned", *Boardwatch,* Feb. 2000 (http://boardwatch.internet.com/mag/2000/feb/bwm48.html)

[38] "2000 Wireless Internet Access Forecast", *Boardwatch*, Feb. 2000 (http://www.boardwatch.com/mag/2000/feb/bwm62.html)

[39] See ATT press release, , " AT&T "Cuts The Cord" To Provide Services Into Homes; Debuts Nation's First Wireless Local Communications Company", March 23,2000 (http://www.att.com/press/item/0,1354,2706,00.html)

[40] "Broadband!", op. cit. p. 31.